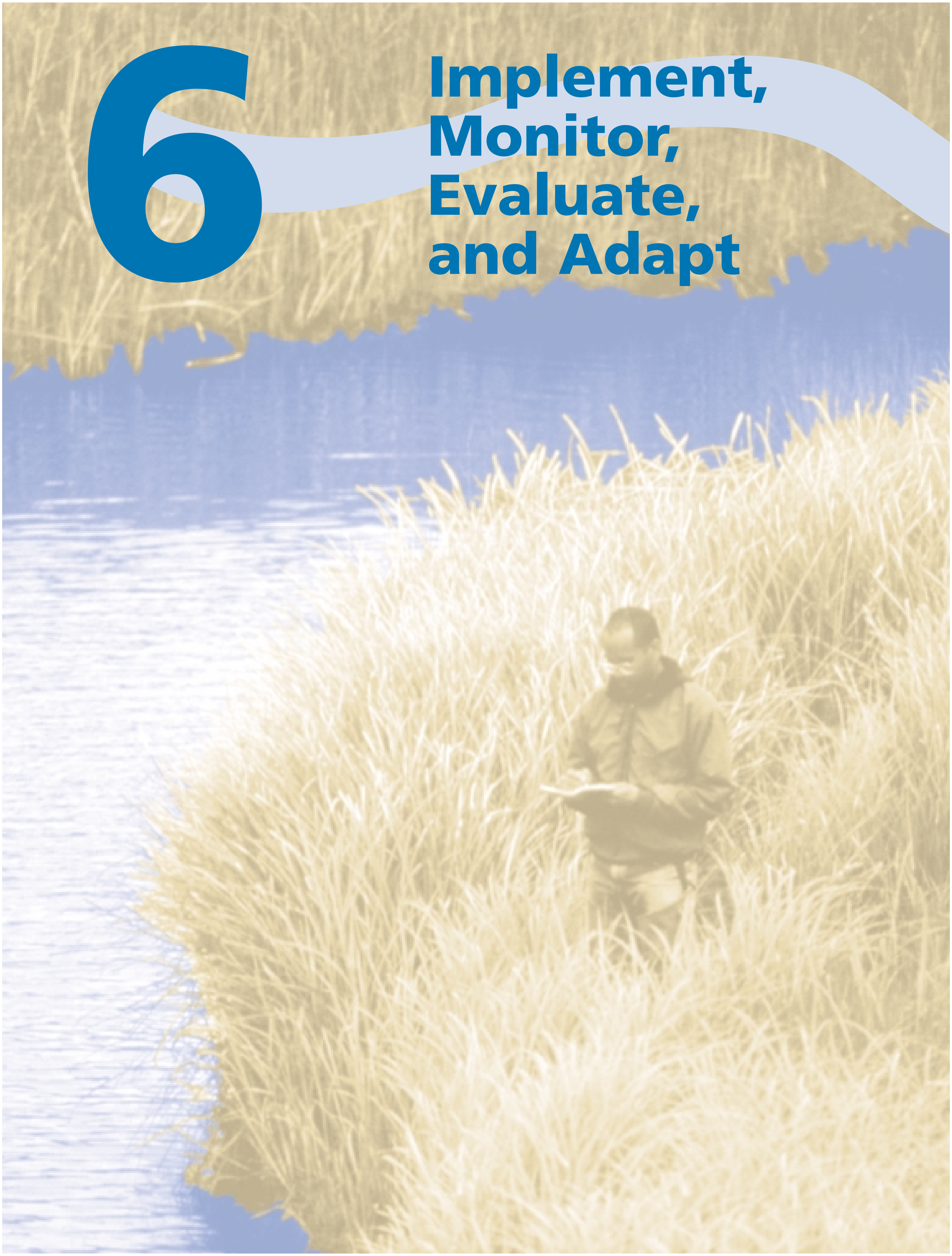
6 Implement, Monitor, Evaluate, and Adapt



6.A Restoration Implementation

- *What are the steps that should be followed for successful implementation?*
- *How are boundaries for the restoration defined?*
- *How is adequate funding secured for the duration of the project?*
- *What tools are useful for facilitating implementation?*
- *Why and how are changes made in the restoration plan once implementation has begun?*
- *How are implementation activities organized?*
- *How are roles and responsibilities distributed among restoration participants?*
- *How is a schedule developed for installation of the restoration measures?*
- *What permits and regulations will be necessary before moving forward with restoration measures?*

6.B Restoration Monitoring, Evaluation, and Adaptive Management

- *What is the role of monitoring in stream corridor restoration?*
- *When should monitoring begin?*
- *How is a monitoring plan tailored to the specific objectives of a restoration initiative?*
- *Why and how is the success or failure of a restoration effort evaluated?*
- *What are some important considerations in developing a monitoring plan to evaluate the restoration effort?*

6 Implementing, Monitoring, Evaluating, and Adapting

The development of restoration goals and objectives and the formulation and selection of restoration alternatives does not mark the end of the restoration plan development process. Successful stream corridor restoration requires careful consideration of how the restoration design will be implemented, monitored, and evaluated. In addition, it requires a commitment to long-term planning and management that facilitates adaptation and adjustment in light of changing ecological, social, and economic factors.

This chapter focuses on the final stages of restoration plan development. It presents the basics of restoration implementation, monitoring, evaluation, and management within a planning context. Specifically, the administrative and planning elements associated with these activities are discussed in detail. This chapter is intended to set the stage for the technical or "how to" discussion of restoration implementation, monitoring, maintenance, and management presented in Chapter 9. The present chapter is divided into two main sections.

Section 6.A: Restoration Implementation

The first section examines the basics of restoration implementation. It includes a discussion of all aspects relevant to carrying out the design, including funding, *incentives, division of responsibilities, and the actual implementation process.*

Section 6.B: Restoration Monitoring, Evaluation, and Adaptive Management

Once the basic design is executed, the monitoring, evaluation, and adaptation process begins. This section explores some of the basic considerations that need to be addressed in examining and evaluating the success of the restoration initiative. In addition, it emphasizes the importance of making adjustments to the restoration design based on information received during the monitoring and evaluation process. Note especially that the plan development process can be reiterated if conditions in or affecting the stream corridor change or if perceptions or goals change due to social, economic, or legal developments.

6.A Restoration Implementation

Implementation is a critical component of the stream corridor restoration process. It includes all the activities necessary to execute the restoration design and achieve restoration goals and objectives. Although implementation is typically considered the "doing," not the "planning," successful restoration implementation demands a high level of advance scheduling and foresight that constitutes planning by any measure.

Securing Funding for Restoration Implementation

An essential component of any stream corridor restoration initiative is the availability of funds to implement the restoration design. As discussed in Chapter 4, identifying potential funding sources should be one of the first priorities of the advisory group and decision maker. By the time the restoration initiative reaches the implementation stage, however, the initial identification of sources should be translated into tangible resource allocations. In other words, all needed funding should be secured so that restoration implementation can be initiated. It is important to remember that financing might ultimately come from several sources. All benefactors, both public and private, should be identified and appropriate cost-sharing arrangements should be developed.

An important element of securing funding for restoration is linking the available resources to the specific activities that will be part of implementation. Specifically, it should be the responsibility of the restoration planners to categorize the various activities that will be part of the restoration, determine how much each activity will cost to implement, and determine how much funding is available for each activity. In performing this analysis it should be noted that funding need not be thought of exclusively in terms of available "cash." Often many of the activities that are part of the restoration effort can be completed with the work of the staff of a participating agency or other organization.

Securing Funding for Anacostia Restoration Initiatives

The Anacostia Watershed Restoration Committee annually seeks funding for many restoration initiatives. In FY91, more than 50 projects were funded by over a dozen local, state, and federal agencies. Funding sources are matched with appropriate watershed projects. In about half a dozen cases, special funding came from federal agencies like the Corps of Engineers, USDA, and EPA. The overwhelming majority of projects, however, involved a skillful coordination of existing sources of support from state and local governmental programs combined with additional help from nongovernmental organizations such as Trout Unlimited and from other citizen volunteers. The signatory agencies (e.g., the District of Columbia, Prince George's and Montgomery Counties, and the state of Maryland) fund most of the storm water retrofit, monitoring, and demonstration projects, as well as public participation activities.

*A key element in maximizing resources from existing programs is the organization of special technical assistance teams for priority subwatersheds (**Figure 6.1**). Subwatershed Action Plan (SWAP) coordinators carry out public education and outreach efforts, and they also assist in comparing the management needs of their subwatersheds with activities of local government. Because many of the problems in the Anacostia relate to urban storm water runoff, many infrastructure projects can have a bearing on restoration needs. When such infrastructure projects are identified, SWAP coordinators try to coordinate with the project sponsor and involve the sponsor in the Anacostia program. If possible, the SWAP coordinator attempts to integrate the retrofit and management objectives of the program and the project.*

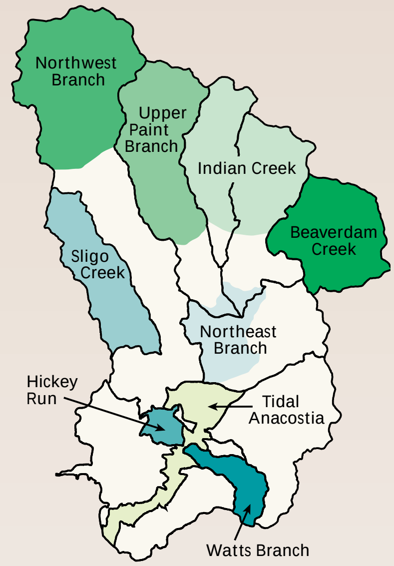


Figure 6.1: Anacostia Basin. *Nine priority subwatersheds compose the Anacostia Basin.* Source: MWCOG 1997. Reprinted by permission.

It is important to note that there might be insufficient funding to carry out all of the activities outlined in the stream corridor restoration design. In this situation, planners should recognize that this is, in fact, a common occurrence and that restoration should proceed. An effort should be made, however, to prioritize restoration activities, execute them as effectively and efficiently as possible, and document success. Typically, if the restoration initiative is demonstrated as producing positive results and benefits, additional funding can be acquired.

Identifying Tools to Facilitate Restoration Implementation

In addition to securing funding, it is important to identify the various tools and mechanisms available to facilitate the implementation of the restoration design. Tools available to the stream corridor restoration practitioner include a mix of both nonregulatory or incentive-based mechanisms and regulatory mechanisms. The *Tools for Facilitating the Implementation of Stream Corridor Restoration Measures* box contains a list and description of some of these tools.

As discussed in Chapter 4, the use of incentives can be effective in obtaining participation from private landowners

REVERSE

Review Chapter 4's conservation easement section.

Important Components of Restoration Implementation

- *Securing Funding for Restoration Implementation*
- *Identifying Tools to Facilitate Implementation*
- *Dividing Implementation Responsibilities*
- *Installing Restoration Measures*

in the corridor and in gaining their support for the restoration initiative (**Figure 6.2**). Incentive programs involving cost shares, tax advantages, or technical assistance can encourage private landowners to implement restoration measures on their property, even if the results of these practices are not directly beneficial to the owner.

In addition to incentives, regulatory approaches are an important option for stream corridor restoration. Regulatory programs can be simple, direct, and easy to enforce. They can be effectively used to control land use and various land use activities.

***Figure 6.2**: Landowner participation.*
Restoration on private lands can be facilitated by landowners.

Deciding which tool, or combination of tools, is most appropriate for the restoration initiative is not an easy endeavor. The following is a list of some important tips that should be kept in mind when selecting among these tools (USEPA 1995a).

- Without targeted and effective education programs, technical assistance and cost sharing alone will not ensure implementation.
- Enforcement programs can also be costly because of the necessary inspections and personnel needed to make them effective.
- The most successful efforts appear to use a mix of both regulatory and incentive-based approaches. An effective combination might include variable cost-share rates, market-based incentives, and regulatory backup coupled with support services (governmental and private) to keep controls maintained and properly functioning.

Dividing Implementation Responsibilities

With funding in place and restoration tools and activities identified, the focus should shift to dividing the responsibilities of restoration implementation among the participants. This process involves identifying all the relevant players, assigning responsibilities, and securing commitments.

Identifying the Players

The identification of the individuals and organizations that will be responsible for implementing the design is

Tools for Facilitating the Implementation of Stream Corridor Restoration Measures

Education	*Programs that target the key audience involved with or affected by the restoration initiative to elicit awareness and support. Programs can include technical information as well as information on the benefits and costs of selected measures.*
Technical Assistance	*One-to-one interaction between professionals and the interested citizen or landowner. Includes provision of recommendations and technical assistance about restoration measures specific to a stream corridor or reach.*
Tax Advantages	*Benefits that can be provided through state and local taxing authorities or by a change in the federal taxing system that rewards those who implement certain restoration measures.*
Cost-share to Individuals	*Direct payment to individuals for installation of specific restoration measures. Most effective where the cost-share rate is high enough to elicit widespread participation.*
Cross-compliance Among Existing Programs	*A type of quasi-regulatory incentive/disincentive that conditions benefits received on meeting certain requirements or performing in a certain way. Currently in effect through the 1985, 1990, and 1996 Farm Bills.*
Direct Purchase of Stream Corridors or of Lands Causing the Greatest Problems	*Direct purchase of special areas for preservation or community-owned greenbelts in urban areas. Costs of direct purchase are usually high, but the results can be very effective. Sometimes used to obtain access to critical areas whose owners are unwilling to implement restoration measures.*
Nonregulatory Site Inspections	*Periodic site visits by staff of local, state, or federal agencies can be a powerful incentive for voluntary implementation of restoration measures.*
Peers	*Simple social acceptance by one's peers or members of the surrounding community, which can provide the impetus for an individual landowner to implement restoration measures. For example, if a community values the use of certain agricultural best management practices (BMPs), producers in those communities are more likely to install them.*

Tools for Facilitating the Implementation of Stream Corridor Restoration Measures (continued)

Direct Regulation of Land Use and Production Activities	*Regulatory programs that are simple, direct, and easy to enforce. Such programs can regulate land uses in the corridor (through zoning ordinances) or the kind and extent of activities permitted, or they can set performance standards for a land activity (such as retention of the first inch of runoff from urban property in the corridor).*
Easements	*Conservation easements on private property are excellent tools for implementing parts of a stream corridor restoration plan (see more detailed discussion in following box). Flowage easements may be a critical component in order to design, construct, and maintain structures and flow conditions.*
Donations	*In some instances, private landowners may be willing, or may be provided economic or tax incentives, to donate land to help implement a restoration initiative.*
Financing	*Normally, a restoration initiative will require multiple sources of funds, and no single funding source may be sufficient. Non-monetary resources may also be instrumental in successfully implementing a restoration initiative.*

essential to successful stream corridor restoration. Since the restoration partners are identified early in the planning process, at this point the focus should be on "reviewing" the list of participants and identifying the ones who are most interested in the implementation phase. Although some new players might emerge, most of the participants interested in the implementation phase will already have been involved in some aspect of the restoration effort (**Figure 6.4**). Typically, partners will change their participation as the process shifts from "evaluating" to "doing."

The decision maker(s), with assistance from the advisory group, should identify the key partners that will be actively involved in the implementation process.

Assigning Responsibilities

To ensure the effective allocation of responsibilities among the various participants, the decision maker(s) and advisory group should rely on a special interdisciplinary technical team. Specifically, the technical team should oversee and manage the implementation process as well as coordinate the work of other participants, such as contractors and volunteers, involved with restoration implementation. The following are some of the responsibilities of the major participants involved in the implementation process.

Conservation Easements

*Conservation easements are an effective stream corridor management tool on private property regardless of whether the stream reach supports high biodiversity or the stream corridor would benefit from active restoration in conjunction with a modification of adjacent land use activities (**Figure 6.3**). Through a conservation easement, landowners receive financial compensation for giving up or modifying some of their development rights while the easement holder acquires the right to enforce restrictions on the use of the property.*

Specific details of a conservation easement are developed on a case-by-case basis. Only those activities which may be considered incompatible with stream corridor management objectives may be restricted. The value of a conservation easement is typically estimated as the difference between the values of the underlying land with and without the restrictions imposed by the conservation easement. Government agencies or non-profit organizations must compensate landowners for the rights they are giving up, but not to exceed more than the results are worth to society. The fair market values of the land before and after an easement is established are based on the "highest and best" uses of the land with and without the restrictions imposed by the easement. Once a conservation easement is established, it becomes part of the title on the property, and any stipulations of the conservation easement are retained when the property is sold. Conservation easements may be established indefinitely or for 25 to 30 years.

Conservation easements may be established with federal agencies, such as the U.S. Fish and Wildlife Service or the Natural Resources Conservation Service, with state agencies, or through nonprofit organizations like The Nature Conservancy or Public Land Trusts. It is often beneficial for federal, state, or local governments to establish conservation easements in partnership with nonprofit organizations. These organizations can assist public agencies in acquiring and conveying easements more efficiently since they are able to act quickly, take advantage of tax incentives, and mobilize local knowledge and support.

Conservation easements are beneficial to all parties involved. The landowners benefit by receiving financial compensation for giving up the rights to certain land use activities, enhancing the quality of the natural resources present on their property, and, when applicable, eliminating problems associated with human use in difficult areas. The quality of the land will also increase as a result of providing increased fish and wildlife habitat, improving water quality by filtering and attenuating sediments and chemicals, reducing flooding, recharging ground water, and protecting or restoring biological diversity. Conservation easements are also beneficial to public resource agencies because, in addition to the public benefit of improved quality of the stream corridor's natural resources, they provide an opportunity for public agencies to influence resource use without incurring the political costs of regulation or the full financial costs of outright land acquisition.

Figure 6.3: Conservation easement. *Conservation easements are an effective tool for protecting valuable areas of the stream corridor.*

REVERSE

Review Chapter4's organizational consideration section.

Interdisciplinary Technical Team

As noted above, the interdisciplinary technical team is responsible for overseeing and coordinating restoration implementation and will assign implementation responsibilities. Before identifying roles, however, the technical team should establish some organizational ground rules. *Some Important Organizational Considerations for Successful Teamwork* reviews some of the important logistical issues that need to be addressed by the team. Organizational considerations are also addressed in Chapter 4.

In addition to establishing ground rules, the technical team should appoint a single project manager. This person must be knowledgeable about the structure, function, and condition of the stream corridor; the various elements of the restoration design; and the policies and missions of the various cooperating agencies, citizen groups, and local governments. When consensus-based decisions are not possible due to time limitations, the project manager must be able to make quick and informed decisions relevant to restoration implementation.

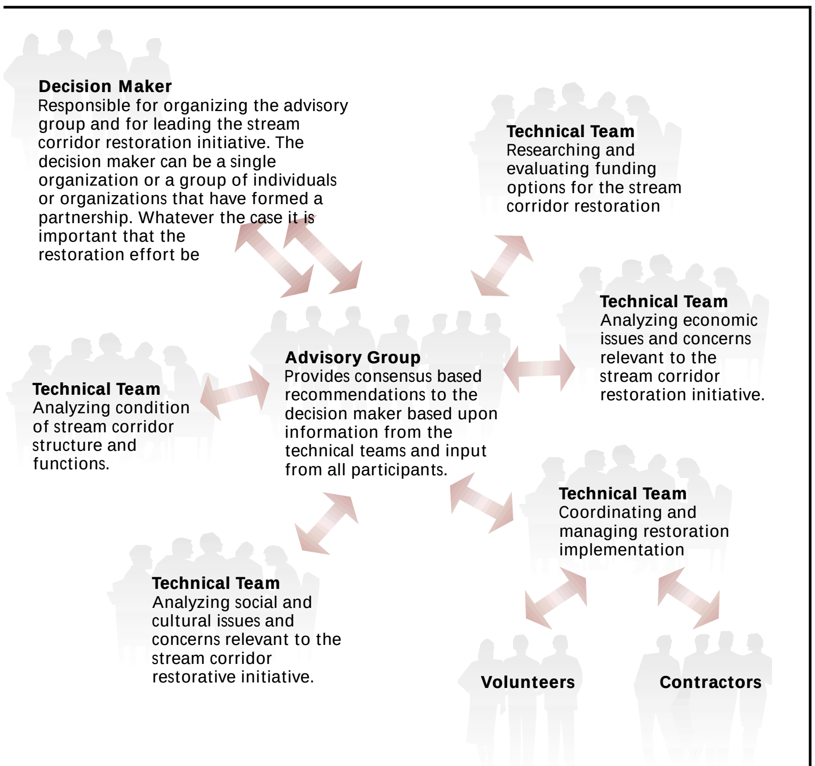


Figure 6.4: Communication flow. *This depicts a possible scenario in which volunteers and contractors may become actively involved.*

Once the organizational issues have been taken care of, the technical team can begin to address its coordination and management responsibilities. In general, the technical team must grapple with several major management issues during the implementation process. The following are some of the major questions that are essential to successful management:

- How much time is required to implement the restoration?
- Which tasks are critical to meeting the schedule?
- What resources are necessary to complete the restoration?
- Who will perform the various restoration activities?
- Is the implementation team adequately staffed?
- Are adequate lines of communication and responsibility established?
- Are all competing and potentially damaging interests and concerns adequately represented, understood, and addressed?

Volunteers

Volunteers can be very effective in assisting with stream corridor restoration (**Figure 6.5**). Numerous activities that are part of the restoration implementation process are suitable for volunteer labor. For example, soil bioengineering and other uses of plants to stabilize slopes are labor-intensive. Two crews of at least two people each are needed for all but the largest installations—one crew at the harvest location and the

Some Important Organizational Considerations for Successful Teamwork

Meeting Mechanics	■ *How often will the team meet?* ■ *Where?* ■ *What will the agenda include?* ■ *How do members get items on the agenda?* ■ *Who will take minutes?* ■ *How will minutes be distributed?* ■ *Who will facilitate the meetings?*
Team Decision Making	■ *How will the team make decisions (vote, consensus, advise only)?* ■ *What decisions must be deferred to higher authorities?*
Problem Solving	■ *How will problems be addressed?* ■ *How will disagreements be resolved?* ■ *What steps will be taken in the event of an impasse?*
Communication and Information	■ *What additional information does the team need to function?* ■ *How will necessary information be shared among team members, and by whom?* ■ *Who handles public relations?*
Leadership Support	■ *What is needed from supervisors and/or managers to ensure project success?*

other at the implementation site. However, a high level of skill or experience is often not required except for the crew leader, and training can commonly occur on the job. Restoration installations involving plant materials are therefore particularly suitable for youth, Job Corps, or volunteer forces.

It should be noted that the use of volunteers is not without some cost. Equipment, transportation, meals, insurance, and training might all be required, and each carries a real dollar need that must be met by the project budget or by a separate agency sponsoring the volunteer effort. However, those

Figure 6.5: Volunteer team. *Volunteers can perform important functions during the restoration implementation process.*

costs are still but a fraction of what would otherwise be needed for nonvolunteer forces.

Contractors

Contractors typically have responsibilities in the implementation of the restoration design. In fact, many restoration efforts require contracting due to the staff limitations of participating agencies, organizations, and landowners.

Contractors can assist in performing some of the tasks involved in implementing restoration design. Specifically, they can be hired to perform various tasks such as channel modification, installation of instream structures, and bank revegetation (**Figure 6.6**). All tasks performed by the contractor should be specified in the scope of the contract and should be subject to frequent and periodic inspection to ensure that they are completed within the proper specifications.

Figure 6.6: Contractor team. *Contractors can assist in performing tasks that might be involved in restoration such as installing bank stabilization measures.*
Source: Robin Sotir and Associates.

Although the contract will outline the role the contractor is to perform, it might be helpful for the technical team (or a member of the technical team) to meet with the contractor to establish a clear understanding of the respective roles and responsibilities. This preinstallation meeting might also be used to formally determine the frequency and mechanisms for reporting the progress of any installation activities. On the next page is a checklist of issues that are helpful in determining some of the roles and responsibilities associated with using contractors to perform restoration-related activities.

Securing Commitments

The final element of the division of responsibilities is securing commitments from the organizations and individuals that have agreed to assist in the implementation process. Two types of commitments are particularly important to ensuring the success of stream corridor restoration implementation (USEPA 1995):

- Commitments from public agencies, private organizations, individuals, and others who will fund and implement programs that involve restoration activities.
- Commitments from public agencies, private organizations, individuals, and others who will actually install the restoration measures.

One tool that can be used to help secure a commitment is a Memorandum of Understanding (MOU). An MOU is an agreement between two or more parties that is placed in writing. Essentially, by documenting what each party specifically agrees to, defining ambiguous concepts or terms, and outlining a conflict resolution process in the event of

Some Issues That Should Be Considered in Addressing Contractor Roles and Responsibilities

- *What constitutes successful completion of the contract obligations by the contractor?*
- *What is the planned order of work and necessary scheduling?*
- *Who is responsible for permitting?*
- *Where are utilities located and what are the related concerns?*
- *What is the relationship between the prime contractor and subcontractors? (In general, the chain of communication should always pass through the prime contractor, and the prime contractor's representative is always present on site. Normally, clients reserve the right to approve or reject individual subcontractors.)*
- *What records and reports will be needed to provide necessary documentation (forms, required job site postings, etc.)?*
- *What arrangements are needed for traffic control?*
- *What specific environmental concerns are present on the site? Who has permit responsibility, both for obtaining and for compliance?*

misunderstandings, an MOU serves to formalize commitments, avoid disappointment, and minimize potential conflict.

A second tool that can be effective is public accountability. As emphasized earlier, the restoration process should be an "open process" that is accessible to the interested public. Once written commitments have been made and announced, a series of periodic public meetings can be scheduled for the purpose of providing updates on the attainment of the various restoration activities being performed. In this way, participants in the restoration effort can be held accountable.

Installing Restoration Measures

A final element of stream corridor restoration implementation is the initiation of management and/or installation of restoration measures in accordance with the restoration design (**Figure 6.7**). If the plan involves construction, implementation responsibilities are often given to a private contractor. As a result, the contractor is required to perform a variety of restoration implementation activities, which can include large-scale actions like channel reconfiguration as well as small-scale actions like bank revegetation.

Whatever the scale of the restoration action, the process itself typically involves several stages. These stages generally include site preparation, site clearing, site construction, and site inspection. Each stage must be carefully executed to ensure successful installation of restoration measures. (See Chapter 9 for a more detailed explanation of this process.)

In addition to careful execution of the installation process, it is important that all actions be preceded by careful plan-

FAST FORWARD

Preview Chapter 9's restoration measures section.

REVERSE

Review Chapter 5's permit section.

ning. Such preinstallation planning is essential to achieve the desired restoration objectives and to avoid adverse environmental, social, and economic impacts that could result. The following is a discussion of some of the major steps that should be taken to ensure successful implementation of restoration-related installation actions.

Determining the Schedule

Scheduling is a very important and highly developed component of implementation planning and management. For large-scale installation actions, scheduling is now almost always executed with the assistance of a computer-based software program. Even for small actions, however, the principles of scheduling are worth following.

Figure 6.7: Installation of erosion control fabric. *Installing measures can be considered a "mid-point" in restoration and not the completion. Preceding installation is the necessary planning, with monitoring and adaptive management subsequent to the installation.*

Table 6.1: Examples of permit requirements for restoration activities.

Local/State

Permits Required	Activities Covered	Administered By
Varies thresholds and definitions vary by state	e.g., clearing/grading, sensitive/critical areas, water quality, aquatic access	Local grading, planning, or building departments; various state departments

Federal

Permits Required			Activities Covered	Administered By
Section 10, Rivers and Harbors Act of 1849			Building of any structure in the channel or along the banks of navigable waters of the U.S. that changes the course, condition, location, or capacity	U.S. Army Corps of Engineers
Section 404, Federal Clean Water Act	Letters of permission		Minor or routine work with minimum impacts	U.S. Army Corps of Engineers
	Nationwide permits	3	Repair, rehabilitation, or replacement of structures destroyed by storms, fire, or floods in past 2 years	
		13	Bank stabilization less than 500 feet in length solely for erosion protection	
		26	Filling of up to 1 acre of a non-tidal wetland or less than 500 linear feet of non-tidal stream that is either isolated from other surface waters or upstream of the point in a drainage network where the average annual flow is less than 5cfs	
		27	Restoration of natural wetland hydrology, vegetation, and function to altered and degraded non-tidal wetlands, and restoration of natural functions of riparian areas on private lands, provided a wetland restoration or creation agreement has been developed	
	Regional permits		Small projects with insignificant environmental impacts	
	Individual permits		Proposed filling or excavation that causes severe impacts, but for which no practical alternative exists; may require an environmental assessment	
Section 401, Federal Clean Water Act			Water quality certification	State agencies
Section 402, Federal Clean Water Act National Pollutant Discharge Elimination System (NPDES)			Point source discharges, as well as nonpoint pollution discharges	State agencies
Endangered Species Act Incidental Take Permit			Otherwise lawful activities that may take listed species	U.S. Fish and Wildlife Service

For tasks that are part of the actual installation work, scheduling is most efficiently done by the contractor actually charged with doing the work. All supporting activities, both before and during installation, must be carefully scheduled as well and should be the responsibility of the project manager.

Obtaining the Necessary Permits

Restoration installation actions conducted in or in contact with streams, wetlands, and other water bodies are subject to various federal, state, and local regulatory programs and requirements. At the federal level, a number of these are aimed at protecting natural resources values and the integrity of the nation's water resources. As discussed in Chapter 5, most of these require the issuance of permits by local, state, and federal agencies.

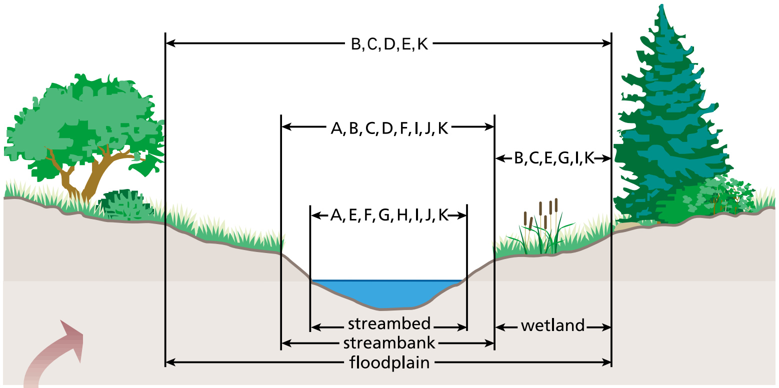
If the action will be conducted or assistance provided by a federal agency, the agency is required to comply with federal legislation, including the National Environmental Policy Act; sections 401, 402, and 404 of the Clean Water Act; the Endangered Species Act; Section 10 of the Rivers and Harbors Act of 1899; executive orders for floodplain management and wetland protection; and possibly other federal mandates depending on the areas that would be affected (see **Table 6.1**).

For example, under the Endangered Species Act, federal agencies must ensure that actions they take will not jeopardize the continued existence of listed threatened or endangered species or destroy or adversely modify their critical habitats (**Figure 6.8**). Where an action would jeopardize a species, reasonable and prudent alternatives must be implemented to avoid jeopardy. In addition, for federal agencies, an incidental take statement is required in those instances where there will be a "taking" of species associated with the federal action. For non-federal activities that might result in "taking" of a listed species, an incidental take permit is required.

Figure 6.8: Southwestern willow flycatcher. *Prior to initiating implementation activities, permits may be needed to ensure the protection of certain species such as the Southwestern willow flycatcher.*

Any work in floodplains delineated for the National Flood Insurance Program might also require participating communities to adhere to local ordinances and obtain special permits.

If the activity will affect lands such as historic sites, archaeological sites and remains, parklands, National Wildlife Refuges, floodplains, or other federal lands, meeting requirements under a number of federal, state, or local laws might be necessary. Familiarity with the likely requirements associated with the activities to be conducted and early contact with permitting authorities will help to minimize delays. Local grading, planning, or building departments are



Using this diagram, determine where your activity will occur. The letters refer to the permits listed below.

	Permit	Government Agency
A	Montana Stream Protection Act (124)	Montana Fish, Wildlife & Parks
B	Storm Water Discharge General Permits	Department of Environmental Quality
C	Streamside Management Zone Law	Department of Natural Resources & Conservation
D	Montana Floodplain and Floodway Management Act	Department of Natural Resources & Conservation
E	Short-term Exemption from Montana's Surface Water Quality Standards (3A)	Department of Environmental Quality
F	Montana Natural Streambed and Land Preservation Act (310)	Montana Association of Conservation Districts and Department of Natural Resources & Conservation
G	Montana Land-use License or Easement on Navigable Waters	Department of Natural Resources & Conservation/ Special Uses
H	Montana Water Use Act	Department of Natural Resources & Conservation
I	Federal Clean Water Act (Section 404)	U.S. Army Corps of Engineers
J	Federal Rivers and Harbors Act (Section 10)	U.S. Army Corps of Engineers
K	Other laws that may apply depending upon your location & activity	various agencies

Figure 6.9: Example of permits necessary for working in and around streams in Montana. *The number of permits required for an aquatic restoration effort may appear daunting but they are all necessary.*
Source: MDEQ 1996. Reprinted by permission.

usually the best place to begin the permit application process. They should be approached as soon as a conceptual outline of the project has been developed. At such a preapplication meeting, the project manager should bring such basic design information as the following:

- A site map or plan.
- A simple description of the restoration measures to be installed.
- Property ownership of the site and potential access route(s).
- Preferred month and year of implementation.

Whether or not that local agency claims jurisdiction over the particular activity, its staff will normally be aware of state and federal requirements that might be applicable. Local permit requirements vary from place to place and change periodically, so it is best to contact the appropriate agency for the most current information. In addition, different jurisdictions handle the designation of sensitive or critical areas differently. Work that occurs in the vicinity of a stream or wetland might or might not be subject to state or local permit requirements unique to aquatic environments. In addition, state and local agencies might regulate other aspects of a project as well.

The sheer number of permits required for an aquatic restoration effort might appear daunting, but much of the required information and many of the remedial measures are the same for all. **Figure 6.9** shows an example of how Montana's permitting requirements mesh with those at the federal level.

Holding Preinstallation Conferences

Preinstallation conferences should be conducted on site between the project manager and supervisor, crew foreman, and contractor(s) as appropriate. The purpose is to establish a clear understanding of the respective roles and responsibilities, and to formally determine the frequency and mechanisms for reporting the progress of the work. In a typical situation, the agency reviews consultant work, provides guidance in the interpretation of internal agency documents or guidelines, and takes a lead or at least supporting role in acquiring permits and satisfying the requirements imposed by regulatory agencies. An additional conference with any inspectors should be held with all affected contractors and field supervisors to avoid potential misunderstandings. Volunteers and noncontractor personnel should also be involved if they are critical to implementation.

At particularly sensitive sites, the need to avoid installation-related damage should be valued at least as highly as the need to complete the planned implementation actions as designed. An on-site meeting, if appropriate to the timing of installation and the seasonality of storms, can avoid many of the emergency problems that might otherwise be encountered in the future. At a minimum, the project manager or on-site superintendent and the local inspector(s) for the permitting jurisdiction(s) should attend. Other people with relevant knowledge and responsibility could also include the grading contractor's superintendent, the civil engineer or landscape architect responsible for the erosion and sediment control plans, a soil scientist or geologist, a biologist, and the plan checker(s) from the permitting jurisdiction(s) (**Figure 6.10**).

The meeting should ensure that all aspects of the plans are understood by the field supervisors, that the key actions and most sensitive areas of the site are recognized, that the sequence and schedule of implementing control measures are agreed upon, and that the mechanism for emergency response is clear. Any changes to the erosion and sediment control plan should be noted on the plan documents for future reference. Final copies of plans and permits should be obtained, and particular attention should be paid to changes that might have been recorded on submitted and approved plan copies, but not transferred to archived or contractor copies.

Involving Property Owners

If possible, the project manager should contact and meet with neighbors affected by the work, including those with site ownership, those granting access and other easements, and others nearby who might endure potential noise or dust impacts.

Securing Site Access

Obtaining right of entry onto private property can be a problematic and time-consuming part of restoration (**Figure 6.11**). Several types of access agreements with differing rights and obligations are available:

- *Right of entry* is the right to pass over the property for a specific purpose for a limited period of time. In many cases, if landowners are involved from the beginning, they will be aware of the need to enter private property. Various types of easements can accomplish this goal.

Figure 6.10: On-site meeting. *Many problems that might otherwise be encountered can be avoided by appropriately timed on-site meetings.*

- *Implementation easement* defines the location, time period, and purpose for which the property can be used during implementation.
- *Access easement* provides for permanent access across and on private property for maintenance and monitoring of a project. The geographic limits and allowable activities are specified.
- *Drainage easement* allows for the implementation and permanent maintenance of a drainage facility at a particular site. Usually, the property owner has free use of the property for any nonconflicting activities.
- *Fee acquisition* is the outright purchase of the property. It is the most secure, but most expensive, alternative. Normally, it is unnecessary unless the project is so extensive that all other potential activities on the property will be precluded.

In many cases little or no money may be exchanged in return for the easement because the landowner receives substantial property improvements, such as stabilized streambanks, improved appearance, better fisheries, and permanent stream access and stream crossings. In some instances, however, the proposed implementation is in direct conflict with existing or planned uses, and the purchase of an easement must be anticipated.

Locating Existing Utilities

Since most restoration efforts have a lower possibility of encountering utilities than other earthwork activities, special measures might not be necessary. If utilities are present, however, certain principles should be remembered (King 1987).

First, field location and highly visible markings are mandatory; utility atlases are notoriously incomplete or inaccu-

***Figure 6.11*: Site access.** *In certain areas, access agreements, such as a right of entry or implementation easement, might have to be obtained to install restoration measures.*

rate. Utilities have a particular size and shape, not just a location, which might affect the nature or extent of adjacent implementation. They also require continuous support by the adjacent soil or temporary restraining structures. Rights-of-way might also create constraints during and after implementation. Even though all potential conflicts between utilities and the proposed implementation should be resolved during implementation planning, field discovery of unanticipated problems occurs frequently. Resolution comes only with the active involvement of the utility companies themselves, and the project manager should not hesitate to bring them on site as soon as a conflict is recognized.

Confirming Sources and Ensuring Material Standards

First, the project manager must determine the final sources of any required fill dirt and then arrange a pickup and/or delivery schedule. The project manager should also confirm the sources of nursery and donor sites for plant materials. Note, however, that delaying the initial identification of these sources until the time of site preparation almost guarantees that the project will suffer unexpected delays. In addition, it is important to double check with suppliers that all materials scheduled for delivery or pickup will meet the specified requirements. Early attention to this detail will avoid delays imposed by the rejection of substandard materials.

Characteristics of Successful Implementation

As was discussed earlier, successful restoration requires the efficient and effective execution of several core implementation activities, such as installing restoration measures, assigning responsibilities, identifying incentives, and securing funding. The Winooski River Case Study is a good example. Cutting across these core activities, however, are a few key concepts that can be considered characteristics of successful restoration implementation efforts.

Characteristics of Successful Implementation

- *Central responsibility in one person*
- *Thorough understanding of planning and design documents*
- *Familiarity with the site and its biological and physical framework*
- *Knowledge of laws and regulations*
- *Understanding of environmental control plans*
- *Communication among all parties involved in the project action*

Central Responsibility in One Person

Most restoration efforts are a product of teamwork, involving specialists from such disparate disciplines as biology, geology, engineering, landscape architecture, and others. Yet the value of a single identifiable person with final responsibility cannot be overemphasized. This project manager ignores the recommendations and concerns of the project team only at his or her peril. Rapid decisions, particularly during implementation, must nonetheless often be made. Rarely are financial resources available to keep all members of the design team on site during implementation, and even if some members are present, the time needed to achieve a consensus is simply not available.

Successful Implementation: The Winooski River Watershed Project, Vermont

In the late 1930s, an extensive watershed restoration effort known as "Project Vermont" was implemented in the Lower Winooski River Watershed, Chittenden County, Vermont. The project encompassed the lower 111 square miles (including 340 farms) of the 1,076-square-mile Winooski River Watershed.

*The Winooski River Watershed sustained severe damage from major floods during the 1920s and 1930s. In addition, overgrazing, poor soil conservation practices on cropland areas, encroachment to the streambanks, and forest clear-cutting also led to excessive erosion (***Figure 6.12***). Annual iceflows and jams during snowmelt runoff further exacerbated riverbank erosion. Throughout the watershed, both water and wind erosion were prevalent. In addition to problems in the low-lying areas, there were many environmental problems to address on the uplands. The soil organic matter was depleted in some areas, cropland had low productivity, pastures were frequently overgrazed, cover for wildlife was sparse, and forest areas had been clear-cut in many areas. In some cases, this newly cleared land was subject to grazing, which created additional problems.*

Figure 6.12: Brushmattress and plantings after spring runoff in March 1938. *Note pole jetties. Brushmatting involves applying a layer of brush fastened down with live stakes and wire.*

The Soil Conservation Service (SCS) joined with the University of Vermont (UVM) and local landowners to formulate a comprehensive, low-input approach to restoring and protecting the watershed. One hundred eighty-nine farmers participated in developing conservation plans for their farms, which covered approximatey 57 square miles. Other cooperators applied practices to another 38-square-mile area. Their approach relied heavily on plantings or a combination of plantings and mechanical techniques to overcome losses of both land and vegetated buffer along the river corridor, and in the uplands to make agricultural land sustainable and to restore deteriorating forestland.

The measures, many of which were experimental at the time, were installed from 1938 to 1941 primarily by landowners. Landowners provided extensive labor and, occasionally, heavy equipment for earthmoving and transportation and placement of materials too heavy for laborers. SCS provided interdisciplinary (e.g., agronomy, biology, forestry, soil conservation, soil science, and engineering) technical assistance in the planning, design, and installation. UVM provided extensive educational services for marketing and operation and maintenance.

In the stream corridor, a variety of measures were implemented along 17 percent of the 33 river miles to control bank losses, restore buffers, and heal overbank floodflow channels. They included the following:

- *Livestock Exclusion: Heavy-use areas were fenced back 15 feet from the top of the bank on straight reaches, 200 feet or wider on the outsides of curves, and 200 feet wide in flood overflow entrance and exit sections.*
- *Plantings and Soil Bioengineering Bank Stabilization: Where the main current was not directed toward the treatment, streambanks were sloped back and planted with more than*

600,000 cuttings and 70,000 plants, primarily willow. Brushmattresses, which involved applying a layer of brush fastened down with live stakes and wire, were used to protect the bank until plantings could be made and established. Where streamflow was directed toward the bank, rock riprap was embedded at the toe up to 2 or more feet above the normal water line. Other toe protection techniques, such as pile jetties, were used.

- *Structures: In reaches where nearshore water was deep (up to 14 feet) and bank voiding was occurring, whole tree deflectors were used to trap sediment and rebuild the voided section. Trees with butt diameters of 2 to 3 feet were placed longitudinally along the riverbank with branches intact and with butts and tops slightly overlapped. The butts were cabled to wooden piles driven 8 to 10 feet into the bank. The slope above the normal waterline was brush-matted and planted.*
- *Log pile check dams were constructed at the entrances of flood overflow channels and filled with one-person-size rocks for ballast. These served as barriers to overbank flow along channels sculpted by previous floods. They were installed in conjunction with extensive buffer plantings, and in some cases, whole tree barricades, that were laced down parallel to the river along the top of the denuded bank.*
- *At overbank locations where flow threatened buffer plantings, log cribs were inset parallel to the bank and filled with rock. Various tree species were planted as a 200-foot or wider buffer behind the cribs. The cribs provided protection needed until the trees became well established.*

In the watershed, the conservation plans provided for comprehensive management for sustainable farming, grazing, forestry, and wildlife. The cropland practices included contour strips, contour tillage, cover crops, crop and pasture rotation, grass and legume plantings, diversions, grassed waterways, log culvert crossings, contour furrows in pastures, livestock fencing, planting of hedgerows, field border plantings, reforestation, and sustainable forest practices.

***Figure 6.13: Same site (Figure 6.12) in April 1995. Note remnants of old jetties and heavy bank cover.** Restoration measures are continuing to function well, more than 55 years after installation.*

Wildlife habitat improvement practices provided connectivity among the cropland, pasture, and forest areas; hedgerow plantings as travelways, food sources, and cover; livestock exclusion areas to encourage understory herbaceous growth for cover and food sources; snags for small mammals and birds; and slash pile shelters as cover for rabbits and grouse.

One reason for this historic project's usefulness to modern environmental managers is the extensive documentation, including photos, maps, and detailed observations and records, available for many of the sites. Complete aerial photography is available from before, during, and after implementation. More than 600 photos provide a chronology of the measures, and three successive studies (Edminster and Atkinson 1949, Kasvinsky 1968, Ryan and Short 1995) document the performance of the project.

*The restoration measures implemented are continuing to function well today, more than 55 years after installation. Tree plantings along the corridor have matured to diameters as great as 45 inches and heights exceeding 100 feet (**Figure 6.13**). The wooded river corridor averages 50 feet wider than it did in the 1930s. Some of the measures have failed, however, including all plantings without toe protection. Lack of maintenance and long-term follow-up also resulted in the failure of restoration efforts at several sites.*

The Winooski River Watershed Project (continued)

Although the Winooski project was experimental in the 1930s, many of its elements were highly successful:

- *Recognition of the importance of landscape relationships and an emphasis on comprehensive treatment of the entire watershed rather than isolated, individual problem areas.*
- *Using an interdisciplinary technical team for planning and implementation.*
- *Strong landowner participation.*
- *Empowerment of landowners to carry out the restoration measures using low-cost approaches (often using materials from the farm).*
- *Fostering the use of experimental methods that are now recognized as viable biotechnical approaches.*

The success of restoration efforts depends more on having a competent project manager than on any other factor. The ideal project manager should be skilled in leadership, scheduling, budgeting, technical issues, human relationships, communicating, negotiating, and customer relations. Most will find this a daunting list of attributes, but an honest evaluation of a manager's shortcomings before restoration is under way might permit a complementary support team to assist the one who most commonly guides restoration to completion.

Thorough Understanding of Planning and Design Materials

Orchestrating the implementation of all but the simplest restoration efforts requires the integration of labor, equipment, and supplies, all within a context determined by requirements of both the natural system and the legal system. Designs must be adequate and based on a foundation of sound physical and biological principles, tempered with the experience of past efforts, both successful and unsuccessful. Schedules must anticipate the duration of specific implementation tasks, the lead time necessary to prepare for those tasks, and the consequences of inevitable delays. A manager who has little familiarity with the planning and design effort can neither execute the implementation plans efficiently nor adjust those plans in the face of unanticipated conditions. A certain amount of flexibility is key. Often specific techniques are tied to specific building material, for example. Adjustments are often made according to what is available.

Familiarity With the Reach

Existing site conditions are seldom as they appear on a set of engineering plans. Variability in landform and vegetation, surface water and ground water flow, and changing site conditions during the interval between initial design and final implementation are all inevitable. There is no substitute for familiarity with the site that extends beyond what is shown on the plans, so that implementation-period "surprises" are kept to a minimum (**Figure 6.14**). Similarly, when such surprises do occur,

Figure 6.14: Workers installing a silt fence. *Familiarity with on-site conditions is critical to successful implementation of restoration measures.*

a sound response must be based on the project manager's understanding of both the restoration goals and the likely behavior of the natural system.

Knowledge of Laws and Regulations

Site work in and around aquatic features is one of the most heavily regulated types of implementation in the United States (**Figure 6.15**). Restrictions on equipment use, season of the year, distance from the water's edge, and types of material are common in regulations from the local to the federal level. Not appreciating those regulations can easily delay implementation by a year or more, particularly if narrow seasonal windows are missed. The cost of a project can also multiply if required measures or mitigation are discovered late in the design or implementation process.

Understanding of Environmental Control Plans

A project in which a designed restoration measure is installed but the ecological structure and function of an area are destroyed is no success. The designer must create a workable plan for minimizing environmental degradation, but the best of plans can fail in the field through careless implementation.

Communication Among All Parties Involved in the Action

Despite the emphasis here on a single responsible project manager, the success of a project depends on regular, frequent, and open communication among all parties involved in implementation—manager, technical support people, contractor, crews, inspectors, and decision maker(s). No restoration effort proceeds exactly according to plans, and not every contingency can be predicted ahead of time. But well-established lines of communication can overcome most complications that arise.

Figure 6.15: Instream construction activity. *Site work in and around aquatic features is one of the most heavily regulated types of activity in the United States and should not be attempted without a sound knowledge of the relevant laws and regulations.*

6.B Restoration Monitoring, Evaluation, and Adaptive Management

FAST FORWARD

Preview Chapter 9's restoration monitoring management section.

The restoration effort is not considered complete once the design has been implemented. Monitoring, evaluation, and adaptive management are essential components that must be undertaken to ensure the success of stream corridor restoration. Each is carried out at a different level depending on the size and scope of the design.

Monitoring includes both pre- and post-restoration monitoring, as well as monitoring during actual implementation. All are essential to determining the success of the restoration design and require a complete picture or understanding of the structure and functions of the stream corridor. Monitoring provides needed information, documents chronological and other aspects of restoration succession, and provides lessons learned to be used in similar future efforts (Landin 1995).

Directly linked to monitoring are restoration evaluation and adaptive management. Using the information obtained from the monitoring process, the restoration effort should be evaluated to ensure it is functioning as planned and achieving the restoration goals and objectives. Even with the best plans, designs, and implementation, the evaluation will often result in the identification of some unforeseen problems and require midcourse correction either during or shortly following implementation. Most restoration efforts will require some level of oversight and on-site adaptive management.

This section examines some of the basics of restoration monitoring, evaluation, and adaptive management. A more detailed discussion on the technical aspects of restoration monitoring management is provided in Chapter 9 of this document.

Monitoring as Part of Stream Corridor Restoration Initiative

Restoration monitoring should be guided by predetermined criteria and checklists and allow for the recording of results in regular monitoring reports. The technical analyses in a monitoring report should reflect restoration objectives and should identify and discuss options to address deficiencies. For example, the report might include data summaries that indicate that forest understory conditions are not as structurally complex as expected in a particular management unit, that this finding has negative consequences for certain wildlife species, and that a program of canopy tree thinning is recommended to rectify the problem. The recommendation should be accompanied by an estimate of costs associated with the proposed action, a proposed schedule, and identification of possible conflicts with other restoration objectives.

Restoration Monitoring, Evaluation, and Adaptive Management

Restoration Monitoring

- *Progress Toward Objectives*
- *Regional Resource Priorities and Trends*
- *Watershed Activities*

Restoration Evaluation

- *Reasons to Evaluate Restoration Efforts*
- *A Conceptual Framework for Evaluation*

Monitoring plans should be conceived during the planning phase when the goals and performance criteria are developed for the restoration effort. Baseline studies required to provide more information on the site, to develop restoration goals, and to refine the monitoring plan often are conducted during the planning phase and can be considered the initial phase of the monitoring plan. Baseline information can form a very useful data set on prerestoration conditions against which performance of the system can be evaluated.

Monitoring during the implementation phase is done primarily to ensure that the restoration plans are correctly carried out and that the natural habitats surrounding the site are not unduly damaged.

Actual performance monitoring of the completed plan is done later in the assessment phase (**Figure 6.16**). Management of the system includes both management of the monitoring plan and application of the results to make midcourse corrections.

Finally, results are disseminated to inform interested parties of the progress of the system toward the intended goals.

Goals of a Restoration Monitoring Plan

- *Assess the performance of the restoration initiative relative to the project goals.*
- *Provide information that can be used to improve the performance of the restoration actions.*
- *Provide information about the restoration initiative in general.*

***Figure 6.16:* Monitoring of revegetation efforts.** *Monitoring the results of revegetation efforts is a critical part of restoring riparian zones along highly eroded channels.*

Components of a Monitoring Plan

Based on a thorough review of freshwater monitoring plans, some of which had been in place for over 30 years, the National Research Council (NRC) recommended the following factors to ensure a sound monitoring plan (NRC 1990):

- Clear, meaningful monitoring plan goals and objectives that provide the basis for scientific investigation.
- Appropriate allocation of resources for data collection, management, synthesis, interpretation, and analysis.
- Quality assurance procedures and peer review.
- Supportive research beyond the primary objectives of the plan.
- Flexible plans that allow modifications where changes in conditions or new information suggests the need.
- Useful and accessible monitoring information available to all interested parties.

The box, *Developing a Monitoring Plan*, shows the monitoring steps throughout the planning and implementation of a restoration. Each step is discussed in this chapter.

When to Develop the Monitoring Plan

The monitoring plan should be developed in conjunction with planning for the restoration. Once the goals and objectives have been established in the planning phase, the condition of the system must be considered.

Baseline monitoring enables planners to identify goals and objectives and provides a basis for assessing the performance of the completed restoration. Monitoring therefore begins with the determination of baseline conditions and continues through the planning and implementation of the restoration plan.

Developing a Monitoring Plan

Step 1: Define the Restoration Vision, Goals, and Objectives

The goals set for the restoration drive the monitoring plan design. Above all, it is important to do the following:

- Make goals as simple and unambiguous as possible.
- Relate goals directly to the vision for the restoration.
- Set goals that can be measured or assessed in the plan.

Developing Performance Criteria Involves:

- *Linking criteria to restoration goals.*
- *Linking criteria to the actual measurement parameters.*
- *Specifying the bounds or limit values for the criteria.*

Step 2: Develop the Conceptual Model

A conceptual model is a useful tool for developing linkages between planned goals and parameters that can be used to assess performance. In fact, a conceptual model is a useful tool throughout the planning process. The model forces persons planning the restoration to identify direct and indirect connections among the physical, chemical, and biological components of the ecosystem, as well as the principal components on which to focus restoration and monitoring efforts.

Baseline studies might be necessary to meet the following needs:

- To define existing conditions without any actions.
- To identify actions required to restore the system to desired functions and values.
- To help design the restoration actions.
- To help design the monitoring plan.

Step 3: Choose Performance Criteria

Link Performance to Goals

A link between the performance of the system and the planned goals is critical. If the goals are stated in a clear manner and can be reworded as a set of testable hypotheses, performance criteria can be developed. *Performance criteria* are standards by which to evaluate measurable or otherwise observable aspects of the restored system and thereby indicate the progress of the system toward meeting the planned goals. The closer the tie between goals and performance criteria, the better the ability to judge the success of the restoration efforts.

Developing a Monitoring Plan

A. Planning

Step 1: *Define the restoration, vision, goals, and objectives*

Step 2: *Develop the conceptual model*

Step 3: *Choose performance criteria*

- *Link performance to goals*
- *Develop the criteria*
- *Identify reference sites*

Step 4: *Choose monitoring parameters and methods*

- *Choose efficient monitoring parameters*
- *Review watershed activities*
- *Choose methods for sampling design, sampling, and sample handling/ processing*
- *Conduct sociological surveys*
- *Rely on instream organisms for evidence of project success*
- *Minimize the necessary measurements of performance*
- *Incorporate supplemental parameters*

Step 5: *Estimate cost*

- *Cost for developing the monitoring plan itself*
- *Quality assurance*
- *Data management*
- *Field sampling program*
- *Laboratory sample analysis*
- *Data analysis and interpretation*
- *Report preparation*
- *Presentation of results*

Step 6: *Categorize the types of data*

Step 7: *Determine the level of effort and duration of monitoring*

- *Incorporate landscape ecology*
- *Determine timing, frequency, and duration of sampling*
- *Develop statistical framework*
- *Choose the sampling level*

B. Implementing and Managing

- *Manager must have a vision for the life of the monitoring plan*
- *Roles and responsibilities must be clearly defined*
- *Enact quality assurance procedures*
- *Interpret the results*
- *Manage the data*
- *Provide for contracts*

C. Responding to the Monitoring Results

- *No action*
- *Maintenance*
- *Adding, abandoning, or decommissioning plan elements*
- *Modification of project goals*
- *Adaptive management*
- *Documentation and reporting*
- *Dissemination of results*

Primary Functions of Reference Sites

- *Can be used as models for developing restoration actions for a site.*
- *Provide a target to judge success or failure.*
- *Provide a control system by which environmental effects, unrelated to the restoration action, can be assessed.*

Develop the Criteria

The primary reason for implementing the monitoring plan must be kept in mind: to assess progress and to indicate the steps required to fix a system or a component of the system that is not successful.

Criteria are usually developed through an iterative process that involves listing measures of performance relative to goals and refining them to arrive at the most efficient and relevant set of criteria.

Identify Reference Sites

A reference site or sites should be monitored along with the restored site. Although pre- and post-implementation comparisons of the system are useful in documenting effects, the level of success can be judged only relative to reference systems.

Step 4: Choose Monitoring Parameters and Methods

Monitoring should include an overall assessment of the condition and development of the stream corridor relative to projected trends or "target" conditions. In some cases, this assessment may involve technical analyses of stream flow data, channel and bank condition, bedload measurements, and comparisons of periodic aerial photography to determine whether stream migration and debris storage and transport are within the range of equilibrium conditions. Monitoring may also include forest inventories, range condition assessments, evaluations of fish and wildlife habitat or populations, and measurements of fire fuel loading. In small rural or urban "greenbelt" projects, more general qualitative characterization of corridor integrity and quality might be sufficient.

Numerous monitoring programs and techniques have been developed for particular types of resources, different regions, and specific management questions. For example, general stream survey techniques are described by Harrelson et al. (1994), while a regional programmatic approach for monitoring streams in the context of forest management practices in the Northwest is described in Schuett-Hames et al. (1993). Similarly, monitoring of fish and wildlife habitat quality and availability can be approached from various avenues, ranging from direct sampling of animal populations to application of the habitat evaluation procedures developed and used by the U.S. Fish and Wildlife Service (1980a). Techniques specific to riparian zone monitoring are given by Platts et al. (1987).

Basic Questions to Ask When Selecting Methods for Monitoring

- *Does the method efficiently provide accurate data?*
- *Does the method provide reasonable and replicable data?*
- *Is the method feasible within time and cost constraints?*

Choose Efficient Monitoring Parameters

There are two critical steps in choosing efficient monitoring parameters. The first is to identify parameters to monitor. A scientifically based, relatively easily measured set of parameters that provide direct feedback on success or failure of restoration actions are identified. The NRC (1992) has recommended that at least three parameters should be selected and that they include physical, hydrological, and ecological measures. The second step is to select regional and system-specific parameters. Criteria development must be based on a thorough knowledge of the system under consideration.

Those responsible for resources in the stream corridor must be aware of changing watershed and regional resource priorities. The appropriate place to consider the implications of regional needs is in the context of periodic reevaluation of restoration objectives, which is a function of the monitoring process. Therefore, an annual monitoring report should include recognition of ongoing or proposed initiatives (e.g., changes in regulations, emphasis on restoration of specific fish populations, endangered species listings) that might influence priorities in the restored corridor. Awareness of larger regional programs may produce opportunities to secure funding to support management of the corridor.

Review Watershed Activities

The condition of the watershed controls the potential to restore and maintain ecological functions in the stream corridor. As discussed in Chapter 3, changes in land use and/or hydrology can profoundly alter basic stream interactions with the floodplain, inputs of sediment and nutrients to the system, and fish and wildlife habitat quality. Therefore, it is important that stream corridor monitoring include periodic review of watershed cover and land use, including proposed changes (**Figure 6.17**).

Figure 6.17: Urban sprawl. *Understanding changes in watershed land uses, such as increased urbanization, is an important aspect of restoration monitoring.*
Source: C. Zabawa.

Patterns of water movement through and within the stream corridor are basic considerations in developing objectives, design features, and management programs. Proposals to increase impervious surfaces, develop storm water management systems, or construct flood protection projects that reduce floodplain storage potential and increase surface and ground water consumption are all of legitimate concern to the integrity of the stream corridor. Stream corridor managers should be aware of such proposals and provide relevant input to the planning process. As changes are implemented, their probable influence on the corridor should be considered in periodic reevaluation of objectives and maintenance and management plans.

In rural settings, the corridor managers should be alert to land use changes in agricultural areas (**Figure 6.18**). Conversions between crop and pasture lands might require verification that fencing and drainage practices are consistent with agreed-upon BMPs or renegotiation of those agreements. Similarly, in wildland areas, major watershed management actions (timber har-

REVERSE

Review Chapter 3's land use and hydrology Sections.

vests, prescribed burn programs) should be evaluated to ensure that stream corridors are adequately considered.

Increasing development and urbanization may reduce the ability of the stream corridor to support a wide variety of fish and wildlife species and, at the same time, generate additional pressure for recreational uses. Awareness of development and population growth trends will allow a rational, rather than reactive, adjustment of corridor management and restoration objectives. Proposals for specific implementation activities, such as roads, bridges, or storm water detention facilities, within or near the stream corridor should be scrutinized so that concerns can be considered before authorization of the implementation.

Choose Methods for Sampling Design, Sampling, and Sample Handling and Processing

Parameters that might be included in a restoration monitoring plan are well established in the scientific literature. Any methods used for sampling a particular parameter should have a documented protocol (e.g., Loeb and Spacie 1994).

Conduct Sociological Surveys

Scientifically designed surveys can be used to determine changes in social attitudes, values, and perceptions from prerestoration planning through implementation phases. Such surveys may complement physical, chemical, and biological parameters that are normally considered in a monitoring plan. Sociological surveys can reveal important shifts in the ways a community perceives the success of a restoration effort.

Rely on Instream Organisms for Evidence of Project Success

The restoration evaluation should usually focus on aquatic organisms and instream conditions as the “judge and jury” for evaluating restoration success. Instream physical, chemical, and biological conditions integrate the other factors within the stream corridor. Instream biota, however, have shown sensitivity to complex problems not as well detected by chemical or physical indicators alone in state water quality monitoring programs. For instance, in comparing chemical and biological criteria, the state of Ohio found that biological criteria detected an impairment in 49.8 percent of the situations where no impairment was evident with chemical criteria alone. Agreement between chemical and biological criteria was evident in 47.3 percent of the cases, while chemical criteria detected an impairment in only 2.8 percent of the cases where biological criteria indicated attainment (Ohio EPA 1990). As a result, Ohio’s Surface Water Monitoring and Assessment Program has recognized that biological criteria must play a key role in defining water quality standards and in evaluating and monitoring standards attainment if the goal to restore and maintain the physical, chemical, and biological integrity of Ohio’s waters is to be met.

Figure 6.18: Confinement farm. *Practitioners monitoring stream corridor restoration in rural areas should be aware of changes in agricultural land use.*

Minimize the Necessary Measurements of Performance

A holistic perspective is needed when monitoring restoration performance. Still, monitoring should focus narrowly on the fewest possible measurements or indicators that most efficiently demonstrate the overall condition of the stream corridor system and the success of the restoration effort. Costs and the ability to develop statistically sound data may quickly get out of hand unless the evaluation measures chosen are narrowly focused, are limited in number, and incorporate existing data and work wherever appropriate.

Existing data from state and federal agencies, community monitoring programs, educational institutions, research projects, and sportsmen's and other groups should be considered when planning for restoration evaluation. For example, turbidity data are generally more common than sediment data. If one of the objectives of a restoration effort is to reduce sediment concentrations, turbidity may provide a suitable surrogate measurement of sediment at little or no expense to restoration planners. **Table 6.2** provides some other examples of restoration objectives linked to specific performance evaluation tools and measures.

Incorporate Supplemental Parameters

Although the focus of the monitoring plan is on parameters that relate directly to assessment of performance, data on other parameters are often useful and may add considerably to interpretation of the results. For example, stream flow should be monitored if water temperature is a concern.

Step 5: Estimate Cost

Various project components must be considered when developing a cost estimate. These cost components include:

General Objectives	Potential Evaluation Tools and Criteria
Channel capacity and stability	Channel cross sections
	Flood stage surveys
	Width-to-depth ratio
	Rates of bank or bed erosion
	Longitudinal profile
	Aerial photography interpretation
Improve aquatic habitat	Water depths
	Water velocities
	Percent overhang, cover, shading
	Pool/riffle composition
	Stream temperature
	Bed material composition
	Population assessments for fish, invertebrates, macrophytes
Improve riparian habitat	Percent vegetative cover
	Species density
	Size distribution
	Age class distribution
	Plantings survival
	Reproductive vigor
	Bird and wildlife use
	Aerial photography
Improve water quality	Temperature
	pH
	Dissolved oxygen
	Conductivity
	Nitrogen
	Phosphorus
	Herbicides/pesticides
	Turbidity/opacity
	Suspended/floating matter
	Trash loading
	Odor
Recreation and community involvement	Visual resource improvement based on landscape control point surveys
	Recreational use surveys
	Community participation in management

Table 6.2: Environmental management.
Source: Kondolf and Micheli 1995.

- *Monitoring plan*. Development of a monitoring plan is an important and often ignored component of a monitoring cost assessment. The plan should determine monitoring goals, acceptable and unacceptable results, and potential contingencies for addressing unacceptable results (**Figure 6.19**). The plan should specify responsibilities of participants.
- *Quality assurance (QA)*. The monitoring plan should include an indepen-

dent review to ensure that the plan meets the restoration goals, the data quality objectives, and the expectations of the restoration manager. The major cost component of quality assurance is labor.

- *Data management*. Monitoring plans should have data management specifications that start with sample tracking (i.e., that define the protocols and procedures) and conclude with the final archiving of the information. Major costs include staff labor time for data management, data entry, database maintenance, computer time, and data audits.
- *Field sampling plan*. Sampling may range from the very simple, such as photo monitoring, wildlife observation, and behavioral observation (e.g., feeding, resting, movement), to the more complex, such as nutrient and contaminant measurement, water quality parameter measurement, plankton group measurement, productivity measurement in water column and substrate surface, macrophyte or vegetation sampling, and hydrological monitoring. The cost components for a complex plan may include the following:
  - Restoration management and field staff labor.
  - Subcontracts for specific field sampling or measurement activities (including costs of managing and overseeing the subcontracted activities).
  - Mobilization and demobilization costs.
  - Purchase, rental, or lease of equipment.
  - Supplies.

Figure 6.19: Monitoring. *It is important to develop a framework for the monitoring protocol and a plan for monitoring evaluation.*

  - Travel.
  - Shipping.
- *Laboratory sample analysis*. Laboratory analyses can range from simple tests of water chemistry parameters such as turbidity, to highly complex and expensive tests, such as organic contaminant analyses and toxicity assays. The cost components of laboratory sample analysis are usually estimated in terms of dollars per sample.
- *Data analysis and interpretation*. Analysis and interpretation require the expertise of trained personnel and may include database management, which can be conducted by a data management specialist if the data are complex or by a technician or restoration manager if they are relatively straightforward.

- *Report preparation.* One of the final steps in the monitoring plan is to prepare a report outlining the restoration action, monitoring goals, methods, and findings. These documents are meant to serve as interpretative reports, synthesizing the field and lab data analysis results. These reports are typically prepared by a research scientist with the aid of a research assistant. Report production costs depend on the type and quality of reports requested.
- *Presentation of results.* Though not often considered a critical component of a monitoring plan, presentation of plan results should be considered, including costs for labor and travel.

Step 6: Categorize the Types of Data

Several types of data gathered as part of the monitoring plan may be useful in developing the plan or may provide additional information on the performance of the system. The restoration manager should also be aware of available information that is not part of the monitoring plan but could be useful. Consultation with agency personnel, local universities and consultants, citizen environmental groups (e.g., Audubon chapters), and landowners in the area can reveal important information.

Step 7: Determine the Level of Effort and Duration

How much monitoring is required? The answer to this question is dependent on the goals and performance criteria for the restoration as well as on the type of ecological system being restored. A monitoring plan does not need to be complex and expensive to be effective.

Incorporate Landscape Ecology

The restoration size or scale affects the complexity of the monitoring required. As heterogeneity increases, the problem of effectively sampling the entire system becomes more complex. Consideration must be given to the potential effect on the restoration success of such things as road noise, dogs, dune buggies, air pollution, waterborne contamination, stream flow diversions, human trampling, grazing animals, and myriad other elements (**Figure 6.20**).

Types of Data Important to Various Phases of the Restoration

- *Restoration Planning*
  - *Develop baseline data at the site.*
- *Implementation of Restoration Plan*
  - *Monitor implementation activities.*
  - *Collect as-built or as-implemented information.*
- *Postimplementation*
  - *Collect performance data.*
  - *Conduct other studies as needed.*

Determine Timing, Frequency, and Duration of Sampling

The monitoring plan should be carried out according to a systematic schedule. The plan should include a start date, the time of the year during which field studies should take place, the frequency of field studies, and the end date for the plan. Timing, frequency, and duration are dependent on the aspects of system type and complexity, controversy, and uncertainty.

- *Timing.* The monitoring plan should be designed prior to conducting any baseline studies. A problem often encountered with this initial sampling is seasonality. Implementation may be completed in midwinter, when vegetation and other conditions are not as relevant to the performance criteria and goals of the restoration, which might focus on midsummer conditions.

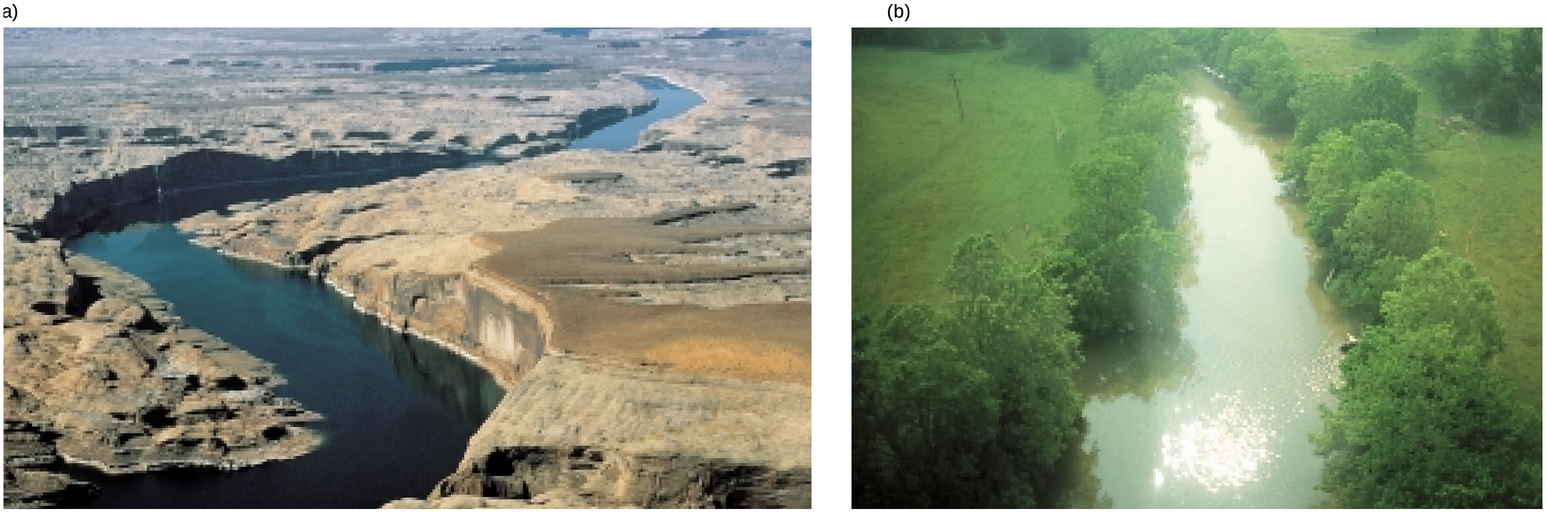
  The field studies should be carried out during an appropriate time of the year. The driving consideration is the performance criteria. Because weather varies from year to year, it is wise to “bracket” the season with the sampling. For example, sampling temperature four times during the midsummer may be better than a single sampling in the middle of the season. Sampling can be performed either by concentrating all tasks during a single site visit or by carrying out one task or a similar set of tasks at several sites in a single day.

- *Frequency.* Frequency of sampling refers to the period of time between samplings. In general, “new” systems change rapidly and should be monitored more often than older systems. As a system becomes established, it is generally less vulnerable to disturbances. Hence, monitoring can be less frequent. An example of this is annual monitoring of a marsh for the first 3 years, followed by monitoring at intervals of 2 to 5 years for the duration of the planned restoration or until the system stabilizes.

- *Duration.* The monitoring plan should extend long enough to provide reasonable assurances either that the system has met its performance criteria or that it will or will not likely meet the criteria. A restored system should be reasonably self-maintaining after a certain period of time. Fluctuations on an annual basis in some parameters of the system will occur even in the most stable mature systems. It is important for the plan to extend to a point somewhere after the period of most rapid change and into the period of stabilization of the system.

igure 6.20: Streams n the (a) western ınd (b) eastern Jnited States. *The vide variability of tream structure and unction among different regions of the country makes standardized restoration evaluation difficult.*

a) (b)



Develop a Statistical Framework

The monitoring study design needs to include consideration of statistical issues, including the location of sample collection, the number of replicate samples to collect, the sample size, and others. Decisions should be made based on an understanding of the accuracy and precision required for the data (**Figure 6.21**). The ultimate use of the data must be kept in mind when developing the sampling plan. It is useful to frequently ask, “Will this sampling method give us the answers we need for planning?” and “Will we be able to determine the success or performance of the restoration?”

Monitoring can consist of many different methods and can occur at varying locations, times, and intensities, depending on the conditions to be monitored. The costs or expenditures of time and resources also vary accordingly. The challenge is to design the monitoring plan to provide, in a cost-efficient and timely manner, accurate information to provide the rationale for decisions made throughout the planning process, and during and after implementation to assess success.

The accuracy of the data to define environmental conditions is of paramount concern, but the acceptable precision of the data can vary, depending on the target of concern. For example, if the amount of pesticides in surface water is a concern, it is much cheaper to assay for the presence of groups of pesticides than to test for specific ones. Also, if overall water quality conditions are needed, seasonal sampling of biological indicators may act as a surrogate for long-term sampling of specific chemical parameters.

Choose the Sampling Level

The appropriate level of sampling or the number of replicates under any particular field or laboratory sampling effort depends on the information required and the level of accuracy needed. Quantity and quality of information desired is in turn dependent in part on the expenditures necessary to carry out the identified components of the sampling plan.

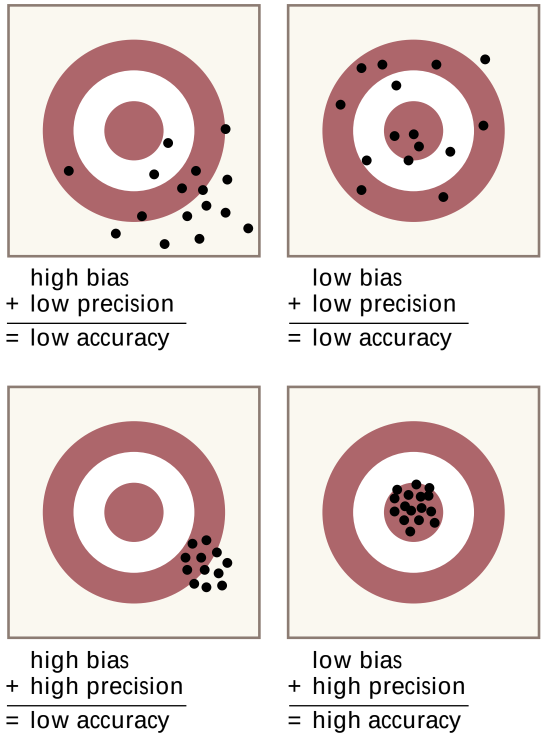


Figure 6.21: Patterns of shots at a target. *Monitoring design decisions should be made based on an understanding of the accuracy and precision required of the data.*
Source: Gilbert 1987 after Jessen 1978.

Implementing and Managing the Monitoring Plan

Management of the monitoring plan is perhaps the least appreciated but one of the most important components of restoration. Because monitoring continues well after implementation activities, there is a natural tendency for the plan to lose momentum, for the data to accumulate with little analysis, and for little documentation and dissemination of the information to occur. This section presents methods for preventing or minimizing these problems.

Envisioning the Plan

The restoration manager must have a vision of the life (i.e., duration) of the monitoring plan and must see how the plan fits into the broader topic of restoration as a viable tool for meeting the goals of participating agencies, organizations, and sponsors.

Determining Roles

Carrying out the monitoring plan is usually the responsibility of the restoration sponsor. However, responsibility should be established clearly in writing during the development of the restoration because this responsibility can last for a decade or more.

Ensuring Quality

The restoration manager should consider data quality as a high priority in the monitoring plan. Scientifically defensible data require that at least minimal quality assurance procedures be in place.

Interpreting Results

Results of the monitoring plan should be interpreted with objectivity, completeness, and relevance to the restoration objectives. The restoration manager and the local sponsor may share responsibility in interpreting the results generated by the monitoring plan. The roles of the restoration manager and local sponsor need to be determined before any data-gathering effort begins. Both parties should seek appropriate technical expertise as needed.

Managing Data

Data should be stored in a systematic and logical manner that facilitates analysis and presentation. Development of the monitoring plan should address the types of graphs and tables that will be used to summarize the results of the monitoring plan. Most monitoring data sets can be organized to allow direct graphing of the data using database or spreadsheet software.

Managing Contracts

One of the most difficult aspects of managing a monitoring plan can be management of the contracts required to conduct the plan. Most restoration requires that at least some of the work be contracted to a consultant or another agency. Because monitoring plans are frequently carried out on a seasonal basis, timing is important.

Restoration Evaluation

Directly linked to monitoring is the evaluation of the success of the restoration effort. Restoration evaluation is intended to determine whether restoration is achieving the specific goals identified during planning, namely, whether the stream corridor has reestablished and will continue to maintain the conditions desired.

Approaches to evaluation most often emphasize biological features, physical attributes, or both. The primary tool of evaluation is monitoring indicators of stream corridor structure, function, and condition that were chosen because they best estimate the degree to which restoration goals were met.

Evaluation may target certain aquatic species or communities as biological indicators of whether specific water quality or habitat conditions have been restored. Or, for example, evaluation may focus on the physical traits of the channel or riparian zone that were intentionally modified by project implementation (**Figure 6.22**). In any case, the job is not finished unless the condition and function of the modified stream corridor are assessed and adjustments, if necessary, are made. The time frame for evaluating restoration success can vary from months to years, depending on the speed of the stream system's response to the treatment applied. Therefore, performance evaluation often means a commitment to evaluate restoration long after it was implemented.

Reasons to Evaluate Restoration Efforts

The evaluation of stream corridor restoration is a key step that is often omitted. Kondolf and Micheli (1995) indicate that despite increased commitment to stream restoration, postrestoration evaluations have generally been neglected. In one study in Great Britain, only 5 of almost 100 river conservation enhancement projects had postimplementation appraisal reports (Holmes 1991).

Why do practitioners of restoration sometimes leave out the final evaluation process? One probable reason is that evaluation takes time and money and is often seen as expendable excess in a proposed restoration effort when it is misunderstood. It appears that the final restoration evaluation is sometimes abandoned so the remaining time and money can be spent on the restoration itself. Although an understandable temptation, this is not an acceptable course of action for most restoration efforts, and collectively the lack of evaluation slows the development and improvement of successful restoration techniques.

Protecting the Restoration Investment

Stream corridor restoration can be extremely costly and represent substantial financial losses if it fails to work properly. Monitoring during and after the restoration is one way to detect problems before they become prohibitively complex or expensive to correct.

Restoration may involve a commitment of resources from multiple agencies,

***Figure 6.22*: Instream modifications.** *Restoration evaluation may focus on the physical traits of the channel that were intentionally modified during project implementation such as the riffles pictured.*

REVERSE

Review Chapter 5's goals and objectives section.

groups, and individuals to achieve a variety of objectives within a stream corridor. All participants have made an investment in reaching their own goals. Reaching consensus on restoration goals is a process that keeps these participants aware of each others' aims. Evaluating restoration success should maintain the existing group awareness and keep participants involved in helping to protect their own investment.

Helping to Advance Restoration Knowledge for Future Applications

Restoration actions are relatively new and evolving and have the risk of failure that is inherent in efforts with limited experience or history. Restoration practitioners should share their experiences and increase the overall knowledge of restoration practices—those that work and those that do not. Shared experience is essential to our limited knowledge base for future restoration.

Maintaining Accountability to Restoration Supporters

The coalition of forces that make a restoration effort possible can include a wide variety of interest groups, active participants, funding sources, and political backers, and all deserve to know the outcome of what they have supported. Sometimes, restoration monitoring may be strongly recommended or required by regulation or as a condition of restoration funding. For example, the USEPA has listed an evaluation and reporting plan in guidance for grants involving restoration practices to reduce nonpoint source pollution. Requirements notwithstanding, it is worthwhile to provide the restoration effort's key financial supporters and participants with a final evaluation. Other benefits such as enhancing public relations or gaining good examples of restoration successes and publishable case histories, can also stem from well-designed, well-executed evaluations.

Acting on the Results

Identified goals and objectives, as discussed in Chapter 5, should be very clear and specific concerning the resulting on-site conditions desired. However, large or complex restoration efforts are sometimes likely to involve a wide range of goals. Restoration evaluations are needed to determine whether the restoration effort is meeting and will continue to meet specific goals identified during planning, to allow for mid-

Reasons to Prepare Written Documentation for the Monitoring Plan

- *Demonstrates that the monitoring plan is "happening."*
- *Demonstrates that the restoration meets the design specifications and performance criteria.*
- *Assists in discussions with others about the restoration.*
- *Documents details that may otherwise be forgotten.*
- *Provides valuable information to new participants.*
- *Informs decision makers.*

course adjustments, and to report on any unanticipated benefits or problems as a result of the program.

The results from a monitoring plan are an important tool for assessing the progress of a restoration and informing restoration decision makers about the potential need for action.

Alternative Actions

Because restoration involves natural systems, unexpected consequences of restoration activities can occur. The four basic options available are as follows:

- *No action.* If the restoration is generally progressing as expected or if progress is slower than expected but will probably meet restoration goals within a reasonable amount of time, no action is appropriate.
- *Maintenance.* Physical actions might be required to keep restoration development on course toward its goals.
- *Adding, abandoning, or decommissioning plan elements.* Significant changes in parts of the implemented restoration plan might be needed. These entail revisiting the overall plan, as well as considering changes in the design of individual elements.
- *Modification of restoration goals.* Monitoring might indicate that the restoration is not progressing toward the original goals, but is progressing toward a system that has other highly desirable functions. In this case, the participants might decide that the most cost-effective action would be to modify the restoration goals rather than to make extensive physical changes to meet the original goals for the restoration.

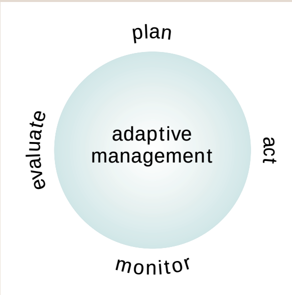
Adaptive Management

The expectations created during the decision to proceed with restoration might not always influence the outcome, but they are certainly capable of influencing the opinions of participants and clients concerning the outcome. The first fundamental rule, then, is to set proper expectations for the restoration effort. If the techniques to be used are experimental, have some risk of failure, or are likely to need midcourse corrections, these facts need to be made clear. One effective way to set reasonable expectations from the beginning is to acknowledge uncertainty, evaluation of performance, and adjustments as part of the game plan.

Adaptive management is not "adjustment management" but a way of establishing hypotheses early in the planning, then treating the restoration process as an experiment to test the hypotheses.

Adaptive management involves adjusting management direction as new information becomes available (**Figure 6.23**). It requires willingness to experiment scientifically and prudently, and to accept occasional failures (Interagency Ecosystem Management Task Force 1995). Since restoration is a new science with substantial uncertainty, adaptive management to incorporate new midcourse information should be expected. Moreover, through adaptive management specific problems can be focused on and corrected.

It is recognized that restoration is uncertain. Therefore, it is prudent to allow for contingencies to address problems during or after restoration implementation. The progress of the system should be assessed annually. At that time, deci-



- *Modify plans using monitoring, technical, and social feedback*
- *Track restoration policy, programs, and individual projects as feedback for further restoration policy and program redesign*
- *Restoration initiatives: recommend annual assessments*
  - *use monitoring data and other data/expertise*
  - *midcourse corrections or alternative actions*
  - *link reporting/monitoring schedules for midcourse corrections*
- *Manager may contract some/all monitoring, but periodically must visit sites, review reports, discuss with contractors.*

Figure 6.23: Adaptive management. *Adjusting management direction as new information becomes available requires a willingness to experiment and accept occassional failures.*

sions can be made regarding any midcourse corrections or other alternative actions, including modification of goals. The annual assessments would use monitoring data and might require additional data or expertise from outside the restoration team. Because the overall idea is to make the restoration "work," while not expending large amounts of funds to adhere to inflexible and unrealistic goals, decisions would be made regarding the physical actions that might be needed versus alterations in restoration goals.

Restoration participants must remain willing to acknowledge failures and to learn from them. Kondolf (1995) emphasizes that even if restoration fails, it provides valuable experimental results that can help in the design of future efforts. Repeatedly, a cultural reluctance to admit failure perpetuates the same mistakes instead of educating others about pitfalls that might affect their efforts, too. Accepting failure reiterates the importance of setting appropriate expectations. Participants should all acknowledge that failure is one of the possible outcomes of restoration. Should failure occur, they should resist the natural temptation to bury their disappointment and instead help others to learn from their experience.

Documenting and Reporting

The monitoring report should also include a systematic review of changes in resource management priorities and watershed conditions along with a discussion of the possible implications for restoration measures and objectives. The review should be wide-ranging, including observations and concerns that might not require immediate attention but should be documented to ensure continuity in case of turnover in personnel. The monitoring report should alert project managers to proposed developments or regulation changes that could affect the restoration effort, so that feedback can be provided and stream corridor concerns can be considered during planning for the proposed developments.

Documentation and reporting of the progress and development of the restoration provide written evidence that the restoration manager can use for a variety of purposes. Three simple concepts are common among the best-documented restorations:

- A single file that was the repository of all restoration information was developed.
- The events and tasks of the restoration were recorded chronologically in a systematic manner.
- Well-written documents (i.e., planning and monitoring documents) were produced and distributed widely enough to become part of the general regional or national awareness of the restoration.

Main sections in a general format for a monitoring report should include title page, summary or abstract, introduction, site description, methods, results, discussion, conclusions, recommendations, acknowledgments, and literature cited.

Dissemination of the Results

Recipients of the report and other monitoring information should include all interested parties (e.g., all state and federal agencies involved in a permit action). In addition, complete files should be maintained. The audience can include beach-goers, birders, fishers, developers, industry representatives, engineers, government environmental managers, politicians, and scientists. The recipient list and schedule for delivery of the reports should be developed by the restoration manager. If appropriate, a meeting with interested parties should be held to present the results of the monitoring effort and to discuss the future of the restoration. Large, complex, and expensive restorations might have wide appeal and interest, and meetings on these restorations will require more planning. Presentations should be tailored to the audience to provide the information in the clearest and most relevant form.

Planning for Feedback During Restoration Implementation

A sound quality control/quality assurance component of the restoration plan incorporates the means to measure and control the quality of an activity so that it meets expectations (USEPA 1995a). Especially in restoration efforts that involve substantial earthmoving and other major structural modifications, risk of unintentional damage to water quality or aquatic biota exists. Midcourse monitoring should be part of the plan, both to guard against unexpected additional damage and to detect positive improvements (**Figure 6.24**).

Making a Commitment to the Time Frame Needed to Judge Success

The time required for system recovery should be considered in determining the frequency of monitoring.

- Data on fractions of an hour might be needed to characterize streamflow.

Figure 6.24: Streambank failure. *Midcourse monitoring will guard against unexpected damages.*

- Hourly data might be needed for water temperature and water quality.
- Weekly data might be appropriate to show changes in the growth rate of aquatic organisms.
- Monthly or quarterly data might be necessary to investigate annual cycles.
- Annual measures might be adequate to show the stability of streambanks.
- Organisms with long life spans, such as paddlefish or trees, might need to be assessed only on the order of decades (**Figure 6.25**).

The time of day for measurement should also be considered. It might be most appropriate to measure dissolved oxygen at dawn, whereas temperature might be measured most appropriately in the mid- to late afternoon. Migrations or climatic patterns might require that studies be conducted during specific months or seasons. For example, restoration efforts expected to result in increased baseflow might require studies only in late summer and early fall.

The expected time for recovery of the stream corridor could involve years or decades, which should be addressed in the duration of the study and its evaluation. Moreover, if the purpose of restoration is to maintain natural floodplain functions during a 10-year flood event, it might take years for such an event to occur and allow a meaningful evaluation of performance.

Some efforts have been made to integrate short- and long-term performance monitoring requirements into overall design. Bryant (1995) recently presented the techniques of a pulsed monitoring strategy involving a series of

Figure 6.25: Revegetated streambank. *Monitoring and evaluation must take into account the differences in life spans among organisms. Tree growth along the streambank will be evaluated on a much longer time scale than other restoration results.*

short-term, high-intensity studies separated by longer periods of low-intensity data collection. MacDonald et al. (1991) have described several different types of monitoring by frequency, duration, and intensity.

Evaluating Changes in the Sources of Stress as Well as in the System Itself

Restoration might be necessary because of stress currently affecting the stream corridor or because of damage in the past. It is critical to know whether the sources of stress are still present or are absent, and to incorporate treatment of the sources of stress as part of the restoration approach. In fact, some practitioners will not enter into a restoration effort that does not include reducing or eliminating the source of negative impacts because simply improving the stream itself will likely result in only temporary enhancements.

The beginning steps of ecological risk assessment are largely designed around characterization of an ecosystem's valued features, characterization of the stressors degrading the ecosystem, identification of the routes of exposure of the ecosystem to the stressors, and description of ecological effects that might result. If these factors are documented for restoration during its design and execution, it should be clear how evaluating performance should address each factor after completion. Has the source of stress, or its route of exposure, been diminished or eliminated? Are the negative ecological effects reversed or no longer present?